

U.S. Fish and Wildlife Service

**Draft Recovery Plan for
Fritillaria gentneri (Gentner's fritillary)**



Cover photo: *Fritillaria gentneri* (Gentner's fritillary) by Brad Tong, Medford District, Bureau of Land Management, used with permission.

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The draft recovery plan was prepared by Steven D. Gisler and Robert J. Meinke, Oregon Department of Agriculture, Native Plant Conservation Program, with the assistance of Andy Robinson, U.S. Fish and Wildlife Service.

EXECUTIVE SUMMARY

Current Status: *Fritillaria gentneri* (Gentner's fritillary) was listed as an endangered species on December 10, 1999 (64 FR 237, 1999). This rare, red-flowered lily is only known from Jackson and Josephine Counties in southwestern Oregon, where it occurs in perilously small, widely scattered patches, comprising an estimated 1,697 flowering individuals.

Habitat Requirements and Limiting Factors: Considered a mid-successional species, *Fritillaria gentneri* occupies grassland and chaparral habitats within, or on the edges of, dry, open, mixed-species woodlands at elevations below 1,360 meters (4,450 feet). The species is threatened by a variety of factors including habitat loss associated with rapidly expanding residential and agricultural development, alteration of habitat by invasive weeds and successional encroachment by trees and brush, habitat disturbance from timber harvest and recreational activities, and vulnerability associated with extremely small population sizes. Other potential threats include bulb collecting for gardens, herbivory by deer, and fungal pathogens.

Recovery Priority Number: This plant's recovery priority is 5 on a scale of 1 to 18, reflecting a species with a high degree of threat and a low potential for recovery.

Recovery Objective: Delisting once recovery criteria have been met.

Recovery Criteria: *Fritillaria gentneri* will be considered for reclassification from endangered to threatened status or delisting when the following criteria are met:

Each recovery zone shall maintain at least 750 flowering plants for reclassification to threatened and 1,000 flowering *Fritillaria gentneri* for delisting when the following criteria are met:

1. To avoid the threat of habitat loss, the reserve areas within the recovery zones identified for recovery should be located on public land, or private land subject to permanent conservation easements or other permanently binding agreements. Because populations elsewhere on public land continue to experience loss and degradation of habitat, each agency involved in land

ownership or management in association with reserve areas should take appropriate steps to ensure the long term conservation of this species by outlining their specific responsibilities for site protection and maintenance in land management plans, conservation agreements, and the like;

2. To remove threats inherent among populations comprised of too few and too widely scattered individuals, 2 of the reserve areas within each recovery zone must consist of at least 100 flowering individuals within a 0.8-kilometer (0.5-mile) radius, and exhibit net demographic stability or growth for at least 15 years, as determined through annual demographic monitoring. For the purposes of this plan, measurements of population size and structure are based only on flowering individuals because non-flowering plants cannot be reliably identified to species. If necessary, reserve areas may be subject to augmentation using genetically appropriate cultivated individuals to meet the minimum size criterion (Recovery Action 2.43). Reserves should contain ample habitat to provide a spatial buffer around each population, and allow room for population migration and expansion over time;
3. To avoid population vulnerability arising from the inordinate concentration of individuals within a very small area, potentially subject to unpredictable catastrophic events, flowering individuals must be distributed over a minimum of 500 square meters (0.05 hectares or 0.12 acres) of occupied habitat within each recovery area;
4. To maintain favorable habitat conditions, each reserve area must be subject to development and implementation of a site-specific habitat management plan to prevent colonization of invasive weeds and maintain favorable habitat characteristics;
5. To protect plants from bulb collecting and herbivory by deer, each reserve area will be subject to fencing or other measures if these threats become recognized as real threats, as determined through annual population monitoring; and,
6. To protect plants from fungal disease, each reserve area will be subject to treatment with fungicides or other measures if fungal infections become recognized as real threats, as determined through annual population monitoring.

Actions Needed: (Refer to Part II of this plan for more detailed descriptions of recovery actions)

1. We shall provide private landowners with information on identification and management of their habitat to maintain *Fritillaria gentneri*.
2. Establish, manage, and maintain a minimum of eight reserve populations, distributed within four recovery zones, where the species will be secure from all threats described in the Reasons for Listing in Part I of this plan (see Part II of this plan for reserve population size and structure requirements).
3. Conduct surveys and research essential to conservation and recovery.
4. Develop an off-site germplasm bank.
5. Review and revise recovery plan as warranted by accumulation of new data.

Estimated Total Cost Necessary to Recover this Species (in \$1,000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Total
FY 1	10	0	141	10	0	161
FY 2	5	0	141	10	0	156
FY 3	5	53	131	10	0	199
FY 4	5	205	20	10	0	240
FY 5	5	215	20	10	0	250
FY 6	5	255	0	10	15	285
FY 7	5	255	0	10	15	285
FY 8	5	255	0	10	0	270
FY 9	5	175	0	10	0	190
FY 10	5	175	0	10	0	190
Total	55	1,588	453	100	30	2,226

Estimated Date of Recovery: 2018

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PART I. INTRODUCTION

A. BRIEF OVERVIEW

Fritillaria gentneri (Gentner's fritillary) was listed as an endangered species on December 10, 1999 (64 FR 237, 1999), under the authority of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.). This rare, red-flowered lily is only known from Jackson and Josephine Counties in southwestern Oregon, where it occurs in perilously small, widely scattered patches of plants comprising an estimated 1,697 flowering individuals. We, U.S. Fish and Wildlife Service, are responsible for preparing a recovery plan for this species that guides its conservation so it can be downlisted from endangered to threatened status, and eventually be delisted. The designation of critical habitat for *Fritillaria gentneri* has not yet been decided (64 FR 237, 1999).

B. SPECIES DESCRIPTION

Fritillaria gentneri, also known as Gentner's mission-bells (cover photo and Figure 1), is a member of the lily family (Liliaceae) with showy, deep red to maroon flowers. The following description of the species is after that of Gilkey's original publication (Gilkey 1951), personal observations by the authors, and the Final Rule for listing the species as endangered (64 FR 237, 1999).

Fritillaria gentneri is a perennial herb arising from a fleshy bulb. Non-flowering individuals vastly outnumber flowering plants in natural populations, and are recognizable only by their single basal leaves, which appear virtually identical to those of other co-occurring *Fritillaria* species. Flowering individuals produce single, erect flowering stems (and no basal leaves) 5 to 7 decimeters (20 to 28 inches) tall, with groups of narrow leaves arranged in several whorls around the stems. The leaves and stems are glaucous (having a blue-grey waxy coating) and are sometimes tinged with purple coloration, especially early in their development. The basal leaf width of non-flowering individuals ranges in size from only 0.2 centimeter (0.08 inches) for young plants arising from small "rice-grain" bulblets, to 7 centimeters (2.8 inches) or more for mature plants with larger bulbs. Flowers are deep red to maroon, usually streaked or mottled with pale yellow, campanulate (bell-shaped), 3.5 to 4 centimeters (1.4 to 1.6 inches) long, with overlapping segments keeled beneath by long, conspicuous nectar-producing glands. These glands range in length from 12 to 18 millimeters long with gland to petal length ratios ranging from 39 to 56 percent (Brock and Callagan 2001). In *Fritillaria recurva* (scarlet fritillary), the glands range in length from 6 to 12

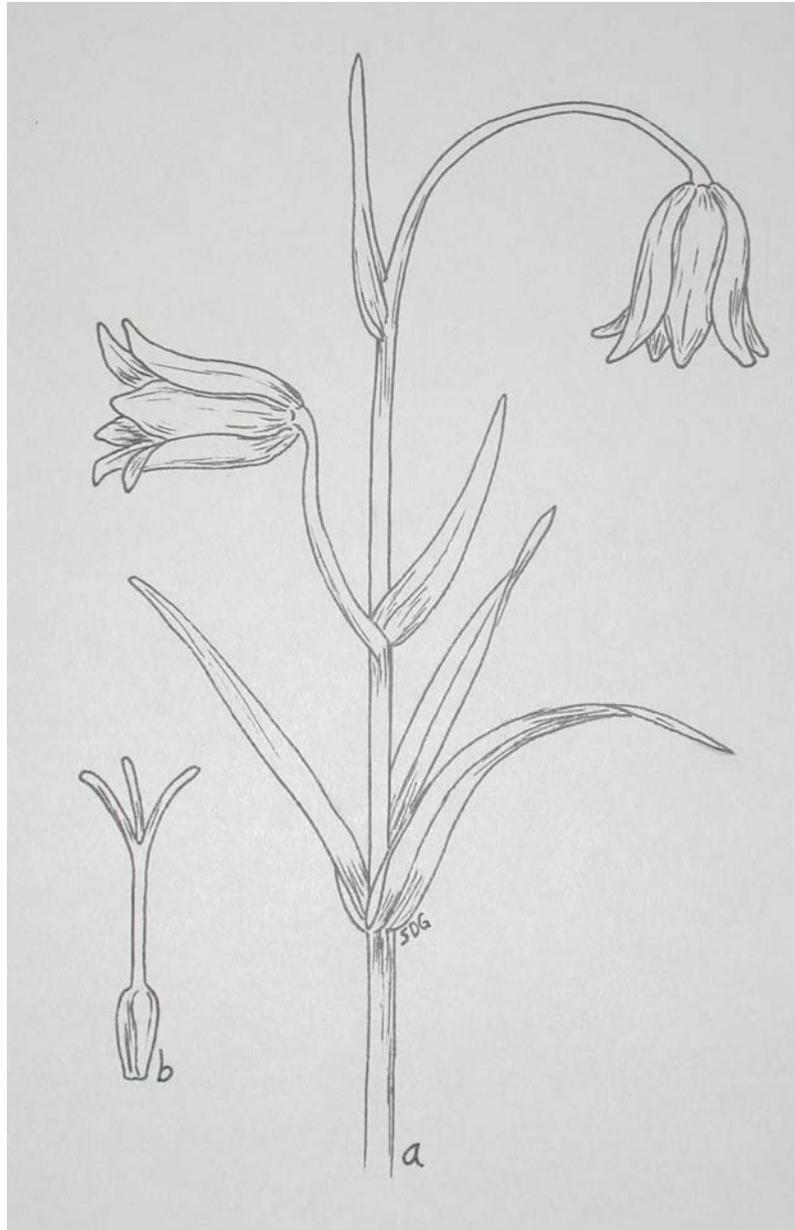


Figure 1. (a) Line drawing of *Fritillaria gentneri* (Gentner's fritillary), (b) gynoecium showing deeply cleft style, a diagnostic feature of this species. (Steven D. Gisler, used with permission)

millimeters with gland to petal length ratios ranging from 22 to 44 percent (Brock and Callagan 2001). Flowers can be solitary or occur in bracted racemes with long, slender pedicels (the stalks supporting a single flower). Stamens (pollen-producing reproductive organs) are included within the flower, rather than exerted beyond the opening as in some other lilies, and the style (the slender, elongated portion of the pistil connecting the stigma to the ovary) is deeply split about half its length. Stigma lobes ranged in length from 6 to 10 millimeters with stigma to style length ratios ranging from 32 to 50 percent (Brock and Callagan 2001). In *Fritillaria recurva*, stigma lobes range in length from 1 to 9 millimeters with stigma to style length ratios ranging from 10 to 37 percent (Brock and Callagan 2001). The fruit is a capsule truncate or rounded at the apex, truncate to slightly cordate at the base, reaching 2 to 2.5 centimeters in length, 2.5 to 3.5 centimeters in width, broadly winged, and wings dentate (Gilkey 1951). Additional descriptions and illustrations of *Fritillaria gentneri* can be found in Peck (1961), Turrill and Sealy (1980), and Meinke (1982).

Fritillaria gentneri co-occurs with two other more common and geographically widespread *Fritillaria* species: *Fritillaria recurva* (scarlet fritillary) and *Fritillaria affinis* (= *F. lanceolata*) (chocolate lily). *Fritillaria gentneri* can be distinguished from these related taxa in several ways. Although flowers of *F. gentneri* and *F. affinis* both exhibit yellow mottling, the base color of *F. gentneri* flowers is deep red to maroon, whereas that of *F. affinis* is plainly brown to purple-brown (Figure 2). Like those of *F. gentneri*, flowers of *F. recurva* are also red, but they are a noticeably brighter, yellowish shade of red, verging to pale orange (Figure 2). Color differences aside, *F. gentneri* and *F. recurva* can also be distinguished by several other floral characteristics. Living up to the specific name, *F. recurva*, it possesses flowers that recurve strongly at the tips, whereas *F. gentneri* flowers simply flare at the tips, or very weakly reflex (Figure 2). Flowers of *F. recurva* are typically narrower, and less bell-shaped, than those of *F. gentneri*, though this character can be variable. One of the most useful diagnostic floral features for distinguishing these species is the style, which is split about half its length in *F. gentneri* but only one-fourth to one-third its length in *F. recurva*. Ultimately, due to morphological variability within *F. gentneri*, it is often necessary to examine all the aforementioned traits together to accurately identify the species.

C. REPRODUCTIVE ECOLOGY

Fritillaria gentneri is a perennial species that reproduces clonally, or asexually, by means of numerous small “rice-grain” bulblets that break off larger bulbs and



Figure 2. Photograph showing comparative floral features of three co-occurring *Fritillaria* species: *Fritillaria gentneri* (center), *F. affinis* (left), and *F. recurva* (right) (photo by Dr. Robert Meinke, used with permission).

form new plants. It is common in nature to observe as many as 40 to 60, or more, individuals arising from these bulblets, with their narrow leaves densely clustered around the base of a single mature plant (Figure 3). When these young individuals are considered, along with other, larger, non-reproductive plants, the number of individuals actually in flower generally makes up only a small fraction of the total population size at any given site. Using data (Appendix B) provided by Brock and Callagan (2000), current estimates indicate that for every flowering *Fritillaria gentneri* there are on average 14.7 vegetative juvenile plants within 20.3 centimeters (8 inches) of the base of flowering plants (95 percent confidence interval is from 9.5 to 19.9 vegetative plants). The lifetime output of bulblets from a single mature bulb is unknown, as is the life span of individuals, and how many growing seasons are required for young plants to reach reproductive maturity. In some other *Fritillaria* species, rice-grain bulblets require 3 to 5 years to reach maturity (Pratt and Jefferson-Brown 1997). Observations in the field suggest some mature plants may remain reproductive over many consecutive years, whereas others may periodically return to a vegetative condition (each producing a single leaf rather than a flowering stem), or a dormant condition under the soil surface, producing no leaves at all.



Figure 3. Mature *Fritillaria gentneri* bulbs produce dozens of rice-grain bulblets, resulting in dense clusters of young individuals that vastly outnumber flowering plants in populations. As discussed later in this plan, such bulblets could prove instrumental in future off-site cultivation and population augmentation projects (photo by Dr. Robert Meinke, used with permission).

Despite the production of showy red flowers, which attract hummingbirds (Amsberry, Oregon Department of Agriculture, unpublished data) and, presumably, bumblebees (E. Guerrant, *in litt.* 1998), there is considerable uncertainty about the ability of *Fritillaria gentneri* to reproduce sexually (i.e., by seeds). There is some indication that the species is, to some extent, capable of producing fruits and seeds. The original description of *Fritillaria gentneri* by Gilkey in 1951 includes information on fruit characteristics, which implies that some fruits must have been formed, although the presence and viability of any seeds contained therein is unknown. Likewise, over the years since its description there have been numerous reports of both fruit and seed production in *Fritillaria gentneri* (Rolle 1988, Guerrant 1992). However, although *Fritillaria gentneri* may occasionally produce capsules and seeds, there is no documented evidence that such seeds are viable.

Studies conducted by Dr. Darlene Southworth of Southern Oregon University indicated low germinability of *Fritillaria gentneri* pollen in the laboratory, which

may account for low fruit and seed production (D. Southworth, pers. comm. 2001). These findings may not reflect germination rates under natural conditions, and may not accurately reflect pollen viability, *per se*. Pollen inviability could explain the results of reproductive studies carried out by the Oregon Department of Agriculture (Oregon Department of Transportation) in 2000 and 2001, where hundreds of flowers at three different sites were subjected to a variety of experimental pollination treatments (including within-plant, between-plant, between-population, and between-species crosses). All of these plants failed to produce even a single fruit or seed (R. Meinke, pers. comm. 2001). These results suggest that seed production is probably limited by high levels of sterility, rather than by self-incompatibility mechanisms or severe inbreeding depression arising from matings between genetically uniform clones within sites.

Demographic study plots established in the Jacksonville Woodlands in 1999 and resampled in 2000 identified 228 individual *Fritillaria gentneri*; 76 of which were considered large (leaf width 2 centimeters or greater). This study (Brock and Knapp 2000) found 14 flowering *Fritillaria gentneri* plants and 21 non-flowering *Fritillaria gentneri* plants that had a leaf width of 4.5 centimeters (considered mature) or greater in 1999. No plants with a leaf width of less than 4.5 centimeters in 1999 flowered in 2000. By comparing the 1999 ratio of non-flowering plants to flowering plants, there was 1.5 (21/14) vegetative *Fritillaria gentneri* plants with leaves greater than 4.5 centimeters for every flowering *Fritillaria gentneri*. Three of the *Fritillaria gentneri* that flowered in 1999 did not flower in 2000. This study forms the basis of estimating the number of mature vegetative fritillary that are *Fritillaria gentneri* (Appendix E).

In summary, what is currently known about reproduction in *Fritillaria gentneri* strongly suggests that vegetative reproduction is the primary, if not the exclusive, means of population establishment and growth. Further research is needed, and proposed in this recovery plan, to determine if any exceptional circumstances exist (i.e., in certain parental crosses or within certain populations) whereby *Fritillaria gentneri* can reproduce sexually (Recovery Action 3.7).

D. HABITAT DESCRIPTION

Fritillaria gentneri occurs in the rural foothills of the Rogue and Illinois River valleys in Jackson and Josephine Counties, Oregon, at elevations ranging from approximately 305.9 to 1,542.4 meters (839 to 4,231 feet) above sea level. The species is found in grassland and chaparral habitats within, or on the edge of, dry, open woodlands variably dominated by the following kinds of trees: *Quercus*

garryana (Oregon white oak), *Quercus kelloggii* (California black oak), *Arbutus menziesii* (madrone), *Pseudotsuga menziesii* (douglas fir), and *Pinus ponderosa* (ponderosa pine). Brock and Callagan (2001) reported *Fritillaria gentneri* occurring on 16 habitats (Table 1). The habitat type depends upon which part of the species range you are in and no single habitat description works for the whole range (R. Brock, pers. comm. 2001).

Commonly associated understory shrubs include *Arctostaphylos viscida* (white-leaved manzanita), *Ceanothus cuneatus* (buckbrush), *Ceanothus velutinus* (snowbrush), *Cercocarpus betuloides* (mountain mahogany), and *Rhus diversiloba* (poison oak). *Fritillaria gentneri* is associated with a spectacular diversity of understory herbaceous species, commonly including: *Arabis subpinnatifida* (ashy rock cress), *Astragalus accidens* var. *hendersoni* (Rogue River milkvetch), *Bromus ciliatus* (fringed brome), *Calochortus tolmiei* (cat's-ear), *Cynoglossum grande* (hound's tongue), *Delphinium decorum* (larkspur), *Dodecatheon hendersoni* (Henderson's shootingstar), *Erythronium hendersonii* (pink fawn lily), *Festuca californica* (California fescue), *Festuca idahoensis* (Idaho fescue), *Fragaria vesca* var. *bracteata* (woods strawberry), *Lomatium utriculatum* (fineleaf biscuit-root), *Poa sandbergii* (Sandberg's bluegrass), *Ranunculus occidentalis* (western buttercup), *Sidalcea malvaeflora* (checkermallow), *Stipa lemmonii* (Lemmon's needle grass), *Senecio integerrimus* (tower butterweed), *Vicia americana* (American vetch), and the two other *Fritillaria* species, *Fritillaria affinis* (chocolate lily) and *Fritillaria recurva* (scarlet fritillary) (64 FR 237, 1999, S. Gisler, pers. comm. 2001, R. Meinke, pers. comm. 2001).

E. DISTRIBUTION AND ABUNDANCE

Fritillaria gentneri is restricted to southwestern Oregon, where it is known from scattered localities in the Rogue and Illinois River drainages in Jackson and Josephine Counties (Figure 4). The species is highly localized within a 48-kilometer (30-mile) radius of the Jacksonville Cemetery in Jacksonville, Oregon (Jacksonville Cemetery harbors one of the largest known *Fritillaria gentneri* populations and serves as a convenient center reference point for the species' range). The majority of known individuals (about 73 percent) occur within an 11-kilometer (7-mile) radius of the Jacksonville Cemetery (64 FR 237, 1999). As seen in Figure 4, *Fritillaria gentneri* has a distribution characterized by several distinct clusters of occurrences, as well as two outlying occurrences in the northeast and southeast corners of its range, respectively, which were taken into consideration during the designation of recovery zones in Part II of this plan. It is

Table 1. Habitat types associated with *Fritillaria gentneri* occurrences (Brock and Callagan 2001).

Habitat type	Number of macroplots (percentage)
Oregon white oak woodland	13 (19 %)
Oregon white oak - Douglas fir ecotone	12 (17 %)
Dry Douglas fir forest	8 (11 %)
Moist riparian Douglas fir - white fir forest	6 (9 %)
Mixed hardwood / conifer with black oak, Oregon white oak, Douglas fir, ponderosa pine, and wedgeleaf ceanothus - whiteleaf manzanita in shrub layer	5 (7 %)
Oregon white oak / birchleaf mahogany - wedgeleaf ceanothus ecotonal chaparral	4 (6 %)
Ponderosa pine - Douglas fir forest	3 (4 %)
Oregon white oak / wedgeleaf ceanothus dry chaparral	3 (4 %)
Black oak forest with silktassle, poison oak, mountain mahogany; serpentine influence	3 (4 %)
Grassland / meadow	3 (4 %)
Moist riparian shrub community	3 (4 %)
Moist chaparral with black oak, silktassle, birchleaf mountain mahogany, whiteleaf manzanita; serpentine influence	2 (3 %)
Jeffrey pine - whiteleaf manzanita serpentine site	1 (1 %)
Ecotone between Oregon white oak / serviceberry chaparral and white fir - Douglas fir forest	1 (1 %)
Oregon white oak / Klamath plum woodland	1 (1 %)
Opening in white fir - Douglas fir forest	1 (1 %)

unknown to what extent individual occurrences, or groups of occurrences, comprise distinct biological populations (i.e., groups of interbreeding individuals mutually separated by lack of gene flow). It is hoped that future research proposed in this plan (Recovery Action 3.5) will help resolve this issue and shed light on the extent and distribution of genetic diversity within the species.

To help document and analyze the distribution of *Fritillaria gentneri* occurrences, we divided the entire known geographic range of the species (including all current and historic species' occurrence records) into a longitude-latitude grid containing macroplots 0.1 minute of longitude and 0.1 minute of latitude (about 6.3 acres or 2.56 hectares) in size. Using this methodology, further described in the Final Rule (64 FR 237, 1999), *Fritillaria gentneri* was historically reported from 53 macroplots, though 8 of these have since been extirpated. Prior to this recovery plan, the number of known flowering plants in 1998 within the extant 45 macroplots was estimated at 340 (64 FR 237, 1999).

Since publication of the Final Rule, several new *Fritillaria gentneri* populations have been discovered. A population census of all known occurrences on Bureau of Land Management lands in 2000 documented 677 flowering plants and 3,333 vegetative (Non-flowering) plants (Brock and Callagan 2000). The largest single documented occurrence to date for *Fritillaria gentneri* (Pickett Creek, Grants Pass Resource area, Bureau of Land Management) contained 306 flowering plants in 2000 (Brock and Callagan 2000). The smallest population known is one plant (Brock and Callagan 2000). In 2001, the authors investigated nine potential occurrences that had been reported to us in response to information requests printed in area newspapers, only one of which proved to harbor *Fritillaria gentneri* (the others either contained *Fritillaria recurva*, or no plants were found at all). The new *Fritillaria gentneri* occurrence contained 50 flowering individuals and was located within a macroplot already occupied by the species near Grants Pass, Oregon. Twenty-two new populations were found during the field season of 2001 on Medford Bureau of Land Management lands with a total of 775 flowering plants (Brock and Callagan 2001). In addition to the aforementioned new populations, an extension of an existing population near Grant's Pass was also reported in 2001 (approximately 200 additional plants scattered up the hillside on private land opposite the previously reported roadside patch) (V. Harris, pers. comm. 2001). Precise locations of *Fritillaria gentneri* occurrences are in our files. The current documented estimated population size on all ownerships (private, State, and Federal) is 1,697 flowering *Fritillaria gentneri* on 109 known macroplots (Appendix A).

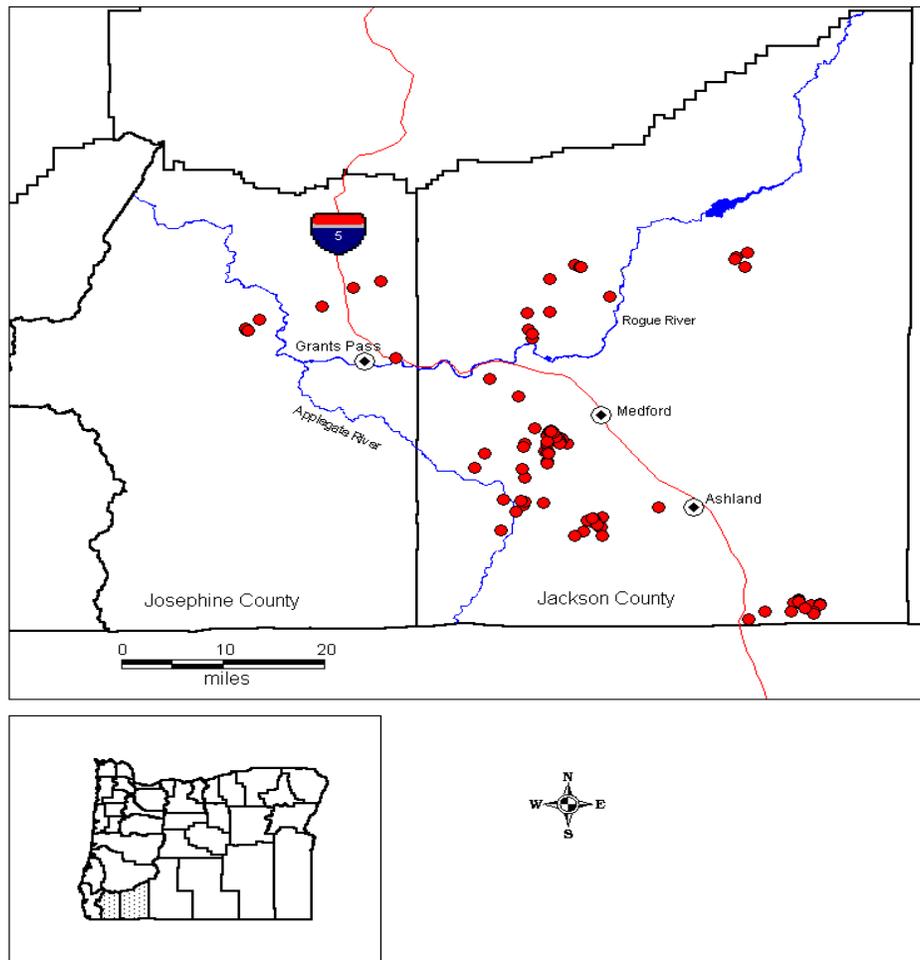


Figure 4. Geographic distribution of known extant *Fritillaria gentneri* occurrences (indicated by dots) in Jackson and Josephine Counties, Oregon. vegetative (non-flowering) plants (Brock and Callagan 2000).

The number of known flowering plants, and our current ability to census flowering individuals, would be expected to fluctuate somewhat between years depending on annual variability in population demography, climate, and levels of herbivory by deer. The total number of *Fritillaria gentneri* individuals in existence is difficult to confidently ascertain because non-flowering plants cannot be distinguished from other co-occurring *Fritillaria* species. Censusing may be further complicated by the fact that many flowering plants are grazed by deer before identification and counting can be performed, and individuals can also remain dormant for 1 or more years under the ground. In 2000, Brock and Callagan surveyed Bureau of Land Management land and found 667 flowering *Fritillaria gentneri* individuals and 3,334 mature vegetative Fritillary individuals (may be Gentner's and/or red-bell). Based on these data (Brock and Callagan 2000), current estimates are that for every flowering *Fritillaria gentneri* individual there is on average 7.0 vegetative mature plants of Gentner's and/or red-bell (95 percent confidence interval is from 4.7 to 9.2 vegetative plants) (Appendix C). It is hoped that future research proposed in this recovery plan (Recovery Action 3.3) will assist in making more accurate counts of non-flowering *Fritillaria gentneri* through development of chemical, anatomical, or other tests to differentiate related species by their leaves.

Ownership information is known for the 109 macroplots historically occupied by the species: 59 macroplots are on lands managed by the Medford District of Bureau of Land Management; 2 are on lands managed by the U. S. Forest Service; 1 is on a right-of-way managed by the Oregon Department of Transportation; 1 occurs on a mixture of private, County parks, and Oregon Department of Transportation lands; 6 occur on lands managed by Southern Oregon University; 8 are on lands managed by the City of Jacksonville and/or the Jacksonville Woodlands Association; and the remaining 32 are on privately owned land (Appendix A). Occupied habitat within macroplots ranges from the space utilized by a single plant (less than 1 square meter or 10.75 square feet) to 1.2 hectares (12,140 square meters or 3 acres) (64 FR 237, 1999).

Surprisingly, despite its showy nature and the fact that botanists have been actively searching for this species for many years, new *Fritillaria gentneri* populations continue to be discovered, even in areas plainly evident from roads and highways. As such, it is hoped that future surveys and new methods of targeting potential habitats, both proposed in this recovery plan (Recovery Actions 3.1 and 3.2, respectively), will further increase the number of known *Fritillaria gentneri* plants and populations, and enhance our knowledge of its geographic range and habitat requirements.

Fritillaria gentneri is not known to grow in exposed areas lacking protection from wind and sun afforded by associated shrubs, nor does it occupy extremely dry sites (64 FR 237, 1999). It grows in areas that experience infrequent human disturbance including roadsides, edges of trails, bulldozer routes, vineyards, and mounds left from past mining activities (W. Rolle, in litt. 1988). As we suggested in the Final Rule (64 FR 237, 1999), *Fritillaria gentneri* probably requires infrequent but regular disturbance (such as the historic pattern of fires in the Rogue and Illinois River valleys) to create openings or edges for colonization. If disturbances fail to maintain such openings, shrubs and trees may eventually encroach into open areas, form thick stands, and shade out *Fritillaria gentneri* and associated understory species.

In 2001, we identified soil types where *Fritillaria gentneri* populations occur, reporting that the species is known to occur on 19 different soil types throughout its geographic range. A table of these soils and the frequency of *Fritillaria gentneri* occurrences on them is provided in Appendix D.

Additional research into *Fritillaria gentneri* habitat requirements and soil affinities is proposed in this recovery plan (Recovery Task 3.3), which may shed more light on the ecological factors contributing to the species' decline, help target future surveys for new populations, and assist land managers in developing effective habitat management plans.

F. REASONS FOR LISTING

Section 4(a)(1) of the Endangered Species Act specifies that species may be determined to be threatened or endangered due to one or more of the reasons listed below, all of which apply to *Fritillaria gentneri*. Removal of these reasons for listing is the ultimate criterion for recovery and delisting, as described in Part II of this plan. Additional details about the reasons for listing can be found in the Final Rule (64 FR 237, 1999).

1. The present or threatened destruction, modification, or curtailment of its habitat or range

Loss of habitat is the core threat to *Fritillaria gentneri*. As stated previously, this species has a very narrow geographic range, and the vast majority of its few remaining occurrences consist mainly of lone plants or small clusters of plants. Because of their small size, individual occurrences are extremely vulnerable to extirpation due to even small-scale losses of habitat.

Since 1982, *Fritillaria gentneri* has been extirpated from 8 of its 53 historic locations (macroplots) due to agricultural development and construction of homes, schools, roads, and driveways. We currently estimate that habitat loss due to ongoing or future development on private lands is likely to occur at 29 percent of remaining macroplots occupied by *Fritillaria gentneri*. Most notable is the Jacksonville Cemetery where at least half the occupied habitat was severely disturbed by bulldozing and road construction in 2001. *Fritillaria gentneri* in the Jacksonville Woodlands has been impacted by trail construction, though efforts are now being made to include the species in project plans to avoid such impacts in the future (General Management Plan, undated).

Although some habitat loss and disturbance continues to occur on Federal lands primarily from timber harvest activities that include road construction, cattrails, and landing decks (64 FR 237, 1999), the areas most threatened are those on private lands where State and Federal laws do not regulate listed plants or their habitat. Of the 109 known macroplots, 32 (29 percent) occur wholly or partially on private lands and are unlikely to persist over the long term, as residential development and detrimental land uses continue to expand. One of the largest known populations, recently discovered on private land near Grants Pass, occupies habitat containing numerous soil test pits for septic tanks, indicating an imminent threat of development that will likely reduce or extirpate the population.

Vehicle use of logging roads on Federal lands for recreational purposes destroys habitat at the end of roads since these areas are used as turn-arounds. This is especially detrimental on ridge-line ecotones, which are typically occupied habitat for *Fritillaria gentneri*.

2. Overutilization for commercial, recreational, scientific, or educational purposes

Given its extreme rarity and striking beauty, *Fritillaria gentneri* may attract horticulturists and bulb fanciers seeking to dig up plants from the wild for cultivation. The fact that this species does not appear to reproduce by seeds provides added incentive for collectors to dig the bulbs, since cultivation by seeds is not possible. Unfortunately, lack of seed production also renders the species more susceptible to the threat of bulb collecting, given the lack of soil seed banks to replenish populations after bulb removal.

Collection of bulbs has already been documented at the Britt Grounds site along

trails. It is estimated that 40 percent of the total number of *Fritillaria gentneri* plants have high potential for collection given their close proximity to roadsides, where they are plainly visible (64 FR 237, 1999). Because the majority of known *Fritillaria gentneri* sites consist of only a few individuals, a single collector could seriously reduce, if not extirpate, an entire macroplot.

3. Disease or predation

Fritillaria gentneri suffers from both disease and predation, which may reduce the health and vigor of plants. Secondary fungal infections have been documented at numerous locations (W. Rolle, in litt. 1988), and the species is apparently highly palatable to deer, resulting in severe levels of herbivory, especially among flowering individuals (W. Rolle, in litt. 1988, Knapp 1999). Reproductive studies conducted by Oregon Department of Agriculture in 2000 and 2001 necessitated the use of heavy-gauge wire mesh cages for the explicit purpose of protecting study plants from herbivory by deer.

The long-term impact of herbivory on *Fritillaria gentneri* is unknown. In a study of translocation of assimilates in the related species, *Fritillaria imperialis* (Crown Imperial fritillary), Van Die (1976) found that lower stem leaves supply resources to the bulb, whereas upper leaves supply resources to flowers and fruits. If this pattern can be generalized to *Fritillaria gentneri*, then herbivory of flowering stems by deer (which typically occurs at or above mid-stem) may have little lasting consequences for bulbs. Intensive grazing by livestock at some sites (i.e., Pelton Lane) may pose a much greater threat than browsing by deer. Likewise, since the species does not appear to produce viable seeds, floral and/or upper stem herbivory may yield little impact aside from depriving human spectators of colorful floral displays. Ultimately, although worthy of serious consideration, the threats associated with disease and herbivory are minimal compared to the immediacy of limitations posed by habitat loss, population fragmentation, and other anthropogenic factors.

4. The inadequacy of existing regulatory mechanisms

Although *Fritillaria gentneri* already falls under the jurisdiction of several existing State and Federal regulatory mechanisms, the protection it receives is inadequate to maintain even the current imperiled status of the species, much less bring about its recovery and long-term stability.

There are several regulations that have been enacted by the State of Oregon that provide some protective measures for *Fritillaria gentneri*. Under the Oregon Wildflower Law (ORS 564.010-040), picking or digging of the fritillary is prohibited within 60.9 meters (200 feet) of any State highway. Considering this law only applies to two macroplots, only regulates collecting activities, carries minimal penalties, and is difficult to enforce, the protection provided by this law is negligible.

Of greater conservation importance is the listing of *Fritillaria gentneri* as endangered by the State of Oregon, as authorized by Senate Bill 533, commonly known as the Oregon Endangered Species Act (ORS 564.100). Under this law, the Oregon Department of Agriculture is responsible for regulating commercial trafficking of the species and developing rules for its protection on all State-owned or State-leased lands, which include all non-Federal public lands. State rules for listed plants stipulate that land managers must conduct surveys prior to implementation of land actions and consult with Oregon Department of Agriculture if they could impact populations of listed species.

As these State rules do not apply to Federal lands or private lands, the only *Fritillaria gentneri* sites that fall under their protection are lands managed by the Oregon Department of Transportation, Southern Oregon University, County lands, and the City of Jacksonville (i.e., the Jacksonville Cemetery and Jacksonville Woodlands). The efficacy of these rules to reliably protect the species on these lands is by no means absolute, as demonstrated by the recent inadvertent destruction of *Fritillaria gentneri* plants and habitat at the Jacksonville Cemetery (R. Meinke, pers. comm. 2001), and other periodic incursions involving other listed taxa throughout the State. Implementation of an outreach program to educate local governmental agencies about their responsibilities under State law may reduce the potential for future inadvertent disturbances involving *Fritillaria gentneri*.

Additional State regulations that apply to *Fritillaria gentneri* include OAR 340-094-0030 and OAR 340-095-0010, which protect federally listed species and their critical habitat from landfill establishment, operation, or expansion. Five of the 109 known macroplots (at least 27 flowering plants) would fall under these protective measures. OAR 141-089-0015 provides protective measures to federally listed species by stating road construction and maintenance activities shall not adversely affect them or their critical habitat, which would overlap protection already afforded to two State highway populations under the Oregon

Endangered Species Act.

Fritillaria gentneri receives protection where it occurs on Federal lands managed by the Bureau of Land Management and U.S. Forest Service. Although no formal conservation agreement has yet been developed between Bureau of Land Management, the Forest Service, and us that specifically applies to *Fritillaria gentneri*, the species is afforded some protection through its Federal listing as an endangered species, which requires the Bureau of Land Management and the Forest Service to enter into consultation with us prior to implementing any actions that may affect the species.

Lastly, *Fritillaria gentneri* is classified by the Oregon Natural Heritage Program as a "G1" category species, which identifies the species as one that is threatened with extinction throughout its entire range. Under this classification, *Fritillaria gentneri* receives general recognition as an imperiled species, but no formal protection.

In summary, although *Fritillaria gentneri* does receive some (albeit still inadequate) protection where it occurs on Federal and State lands, the species still faces serious and imminent threats on private lands, which constitute a significant portion of its range and will play an instrumental role in its continued survival.

5. Other natural or manmade factors affecting its continued existence

Although habitat loss due to development and other land actions represents the most serious threat to *Fritillaria gentneri*, other processes, primarily fire suppression accompanied by ecological succession, are also at work to reduce the quality and quantity of habitat for the species. As stated in our Final Rule (64 FR 237, 1999), the oak woodlands occupied by *Fritillaria gentneri* once experienced a natural fire frequency of every 12 to 15 years, which helped maintain the species' preferred open woodland/grassy understory habitat. Due to 50 to 60 years of fire suppression, these habitats have become more thickly wooded, with closed canopies and development of shrubby understories, resulting in the gradual shading out and displacement of *Fritillaria gentneri*.

Mechanical thinning of overstory shrubs and trees could be used as an alternative to fire as a management tool, though at some sites this might have the negative result of releasing non-native understory species, which could then proliferate and negatively impact *Fritillaria gentneri* through competitive exclusion.

Proliferation of weeds, such as non-native grasses and *Centaurea solstitialis* (yellow star thistle), is already developing into a serious problem at numerous sites, especially those occurring in oak woodland habitats around City of Jacksonville (R. Brock, in litt. 2000).

Development of sound management strategies for *Fritillaria gentneri* is a fundamental objective of this recovery plan, and will be carried out on a site-specific basis for each reserve population. It is hoped proposed research into habitat requirements (Recovery Action 3.2) and responses to experimental management treatments such as burning and overstory thinning (Recovery Action 3.4) will assist in developing these plans in ways that are most beneficial to the species.

Fritillaria gentneri is also endangered by the nature of its remaining populations, which are small in number and in size, and widely scattered in isolated patches. Generally, such small patches are at much higher risk of decline or extirpation than larger populations because they simply lack the demographic reserves needed to maintain them against random losses of individual plants. Such losses could result from diseases, herbivory, natural disturbances, unfavorable climatic events, successional changes, or innumerable potential human impacts. Moreover, because of their limited size, and due to the clonal nature of *Fritillaria gentneri*, these small populations may be additionally disadvantaged due to a paucity of genetically diverse individuals. Genetic uniformity among clones may render populations more vulnerable to pest and disease pressures and environmental changes since they lack the breadth of tolerances, or flexibility, to such pressures that would be afforded by greater adaptive genetic variability.

Likewise, because *Fritillaria gentneri* does not reproduce by seeds (or if so, then very rarely), it not only lacks the ability to rebound from catastrophic events through recruitment from a soil seed bank, but also the ability to respond to environmental changes through the generation of adaptive genetic variation by means of sexual recombination (though at least it does not face the potential complication of inbreeding depression experienced among most sexually reproducing species). As such, if populations contain any genetic diversity at all, it is probably due to founder effects, or possibly the gradual accumulation of mutations over time, which are then maintained in vegetative lineages. Unfortunately, such mutations tend more often to be mildly deleterious, rather than adaptive (Lande 1995), and their accumulation and fixation over time could pose a serious threat to *Fritillaria gentneri* populations.

It is hoped that the size of reserve populations called for in this plan (at least 1,000 flowering individuals each, accompanied and outnumbered by associated non-reproductive plants) will be large enough to provide added stability for the species and minimize the ill consequences of small population sizes discussed above. A brief discussion of the rationale behind the reserve population size criterion is provided in Part II of this recovery plan. The use of herbicides in forestry practice may threaten *Fritillaria gentneri*. Boise Cascade Corporation regularly use herbicides on its land that occurs within the range of *Fritillaria gentneri* (D. Kendig, pers. comm. 2001). The City of Jacksonville uses crossbow herbicide on *Toxicodendron diversilobum* (poison oak) and has not observed a noticeable loss of *Fritillaria gentneri* plants in areas sprayed (B. Schroeder, pers. comm. 2001).

G. CURRENT CONSERVATION MEASURES

Given its State and Federal listing as an endangered species, and its high public profile as a rare and attractive native lily, public agencies, organizations, and individuals have already undertaken numerous conservation measures on behalf of *Fritillaria gentneri*. These include the provision of limited protection afforded by State and Federal regulations, performance of large-scale habitat surveys and multi-year demographic monitoring of populations, inclusion of the species in land development plans, and undertaking of various research projects. These measures are discussed in greater detail below.

1. Regulatory measures

We listed *Fritillaria gentneri* as an endangered species in 1999, under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.). This designation requires all Federal agencies to actively pursue efforts to conserve listed species (section 7) and ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of the species or adversely modify its critical habitat. The Endangered Species Act also regulates interstate and foreign trade of listed species.

Fritillaria gentneri is also regulated under Oregon's State Endangered Species Act, where it is listed as an endangered species (OAR 603-73-070). Regulations under State law are similar to those under the Federal Endangered Species Act, requiring all State agencies (including all county, city, and public school and university subdivisions of the State) to ensure that activities they authorize, fund, or carry out on State-owned or

State-leased land are not likely to “take” (defined as “kill or maintain possession”) (ORS 496.004) any State-listed species. State laws also regulate within-State commercial trade in listed species, and their transport on public roads.

Additional State laws, as well as the inadequacy of current regulatory mechanisms to effectively protect *Fritillaria gentneri*, are discussed above in the Reasons for Listing.

2. Surveys

Over the last 4 years, various individuals, organizations, and government agencies have conducted extensive surveys for *Fritillaria gentneri*, resulting in the discovery of many previously unknown populations and relocation of historic occurrences. Since publication of the Final Rule in 1999 (64 FR 237, 1999), the Medford District Bureau of Land Management has moved beyond conducting the habitat surveys regularly associated with individual project clearances, and has undertaken more proactive measures by sponsoring landscape-level surveys for *Fritillaria gentneri* in areas of suitable habitat. In 2001, surveys were conducted on over 2,023 hectares (5,000 acres) of Bureau of Land Management land, resulting in the discovery of 21 new populations. An additional 1,821 hectares (4,500 acres) were surveyed within the Cascade/Siskiyou National Monument, near the existing Soda Mountain population. Bureau of Land Management intends to continue proactive surveys of this nature in the future, provided adequate funding (M. Mousseaux, pers. comm. 2001). Also in 2001, Josephine County conducted habitat surveys on approximately 208 hectares (515 acres) of suitable habitat on County lands, though these efforts revealed no new populations.

Continuation of surveys in the future, as proposed in this recovery plan (Recovery Action 3.1), will be important in solidifying our understanding of the species’ geographic range, distributional patterns, abundance, habitat preferences, and conservation status.

3. Population monitoring

Population monitoring can be a very useful tool for gaining information on the structure of populations, levels of plant reproduction, longevity of individuals, demographic changes in response to time and environmental

variables, and the general conservation status of populations. Monitoring of *Fritillaria gentneri* has been ongoing, in one form or another, for at least the last 13 years. Such efforts were initiated by Rolle in 1988, and in 1990 a monitoring plan that tracked fates of individual flowering plants was implemented for a single site on Bureau of Land Management land (Knight 1991). Since 1998, the scope of population monitoring on Bureau of Land Management land has broadened to include many more sites (Brock and Callagan 2000). In 1999 and 2000, population monitoring was also carried out in demographic study plots located on land managed by the Jacksonville Woodlands Association (Brock and Knapp 2000). To date, these population monitoring efforts have helped reveal important information about *Fritillaria gentneri*, including the presence and extent of plant dormancy, levels of herbivory and disease, phenological responses to climate, changes in numbers of flowering plants over time, transitions of individuals from flowering to non-flowering stages (and vice versa), and indicated management needs of the species at different sites.

4. Habitat management

To our knowledge, little or no active measures have been taken to manage and improve habitat for *Fritillaria gentneri*. Currently, however, land managers are beginning to take such actions into serious consideration. The Medford District Bureau of Land Management has initiated planning for reduction of fuels and thinning of overstory vegetation at one population site, and it is hoped this will some day lead to implementation, accompanied by demographic monitoring of populations to measure the effects of these actions. Likewise, the Jacksonville Woodlands Association has submitted a proposal to conduct similar habitat management treatments on populations located in the Jacksonville Woodlands (M. Mousseaux, pers. comm. 2001). These populations are already subject to annual demographic monitoring by Bureau of Land Management, which would provide a means of assessing the efficacy of different management techniques. Currently, Oregon Department of Transportation has proposed a challenge cost-share agreement with Medford Bureau of Land Management to conduct preliminary research into the effects of burning on *Fritillaria gentneri* within experimental plots, which may reveal important information useful in larger-scale habitat management applications.

Development and implementation of habitat management plans for reserve

populations is a key requirement in the recovery criteria outlined in this plan.

5. Inclusion in land development plans

Fritillaria gentneri has been included in the General Management Plan for the Historic Natural Park and Trail System within the Jacksonville Woodlands (General Management Plan, undated). The lands within the Jacksonville Woodlands are owned by Bureau of Land Management, Southern Oregon University, and the City of Jacksonville. As stated in the General Management Plan, protection of *Fritillaria gentneri* habitat is one of the primary purposes of the Jacksonville Woodlands. The General Management Plan (page 17) goes on to recognize several key responsibilities associated with the management of *Fritillaria gentneri*:

- The species should in no way be harmed, picked, or have its habitat altered.
- Management of the Woodlands must identify and respect the areas where this species occurs.
- The location of habitat and individual plants should not be disclosed to the public.
- Any use of habitat will be strictly prohibited, except for the purpose of research.
- All actions (trail building, bench placement, etc.) on Bureau of Land Management land will have surveys for the presence of *Fritillaria gentneri* and appropriate actions taken to avoid adverse impacts if the plants are present.

If these responsibilities are carried out as stated, they should provide significant protection for *Fritillaria gentneri* in the Jacksonville Woodlands and alleviate threats directly arising through anthropogenic disturbances.

6. Research

Numerous research projects have been conducted to increase our knowledge about *Fritillaria gentneri*. Sponsored by Oregon Department of Transportation and Bureau of Land Management, Guerrant (1992) used electrophoretic techniques to assess the potential hybrid origin of

Fritillaria gentneri and evaluate its validity as a legitimate species. Results of this study were not definitive, but Guerrant concluded that although *Fritillaria gentneri* is probably of hybrid origin (as are the majority of plant species known to science), it likely arose only once, rather than through multiple, independent hybridization episodes where each population occurs. As such, to the best of our knowledge, *Fritillaria gentneri* should be considered a valid species. Additional research into this issue, using DNA fingerprinting techniques, is currently being initiated at Southern Oregon University under the supervision of Dr. Steven Jessup.

In response to the lack of any verifiable evidence of successful sexual reproduction in *Fritillaria gentneri*, Oregon Department of Transportation (in 2000 and 2001) carried out research we sponsored to shed additional light on this aspect of the species' biology. As described in the previous section on reproductive ecology, this study entailed various types of self-, open- and cross-pollination treatments, carried out at several populations. None of these treatments yielded successful seed production, indicating either a high level of sterility in the species, or inexplicable problems associated with the methodology of hand-pollinating *Fritillaria gentneri* flowers (Oregon Department of Transportation, unpublished data).

To help gain a better understanding of potential sterility in *Fritillaria gentneri*, Dr. Darlene Southworth at Southern Oregon University conducted research into the viability of *Fritillaria gentneri* pollen. This research indicated that: (1) pollen of this species appeared viable (non-shrunken) under microscopic examination; (2) pollen grains of *Fritillaria gentneri* were intermediate in size between *Fritillaria recurva* (scarlet fritillary) and *F. affinis* (chocolate lily); and, (3) germination of *Fritillaria gentneri* pollen on an artificial medium was low (just a few percent) compared to that of *Fritillaria recurva* (10 to 20 percent) (D. Southworth, pers. comm. 2001). This research suggests that *Fritillaria gentneri* may be largely male-sterile, though the level of pollen germination under natural environmental and stigmatic conditions remains unknown, as does the extent of sterility among individuals and across populations. Additional research into the potential for viable seed production in *Fritillaria gentneri* is proposed in this recovery plan (Recovery Action 3.7).

Preliminary research is currently underway by Oregon Department of Transportation to investigate the cultivation requirements of *Fritillaria gentneri* in the greenhouse, using wild-collected bulbs and rice-grain bulblets salvaged from ground disturbance at the Jacksonville Cemetery. Use of bulblets for off-site cultivation will be instrumental in augmenting existing populations in the wild, mitigating population declines due to habitat loss and disturbance, and enhancing reserve populations to meet the minimum size requirements specified in Part II of this recovery plan. Additional research into *Fritillaria gentneri* cultivation requirements is currently being proposed by Oregon Department of Transportation as a challenge cost-share project with Medford Bureau of Land Management. If funded, this research will evaluate the effectiveness of different methods of cultivation and outplanting for successful establishment in the wild, thus, potentially providing the knowledge needed to develop an effective re-introduction strategy for the species.

H. RECOVERY STRATEGY

Fritillaria gentneri will be conserved by establishing a network of protected populations in natural habitat distributed throughout its native range. *Fritillaria gentneri*, a clonal species, has a very low density with the average density per 0.4 hectare (per 1 acre) in occupied habitat being 3.3 flowering plants with the highest being 48 flowering plants at Pickett Creek 3 macroplot. Yonezawa *et al.* (2000) indicated a minimum of 20,000 individuals (flowering and non-flowering) would be needed to conserve normal levels of adaptive genetic variance under a balance of mutation and random genetic drift in populations of the related clonal species, *Fritillaria camtschatcensis* (Kamchatka fritillary). If these findings can be generalized to *Fritillaria gentneri*, then reserve population sizes of 1,000 flowering individuals should be adequate to maintain sufficient adaptive genetic variance, as flowering individuals are typically vastly outnumbered by accompanying non-flowering plants. A population with 1,000 flowering plants is estimated to range from 20,863 to 61,278 total plants (Appendix E). Known *Fritillaria gentneri* locations were plotted on a map, and any area where four or more known locations occurred within 0.5-kilometer (0.3-mile) of each other was considered a “population center”. Through this analysis, 11 population centers were identified. A circle (15.0 kilometers or 9.3 miles in radius) was then created around each population center. Up to 4 recovery zones (units) were identified around each of these 11 population centers (Figure 5). Where the concentric circles around one population center intersect with concentric circles around another population center, the circles join to form “bands” that continue around, in many cases, two to six population centers (Figure 5). No plants are known to

occur beyond 15.0 kilometers (9.3 miles) of any of the 11 population centers. The two recovery zones that are the closest to each other are recovery zones 1 and 3, but are separated by the Rogue River. The strategy for each recovery zone will include rehabilitation of habitat, restoration of extant historic sites, augmentation of existing macroplots, and creation of populations in never before occupied macroplots with suitable habitat. Furthermore, to ensure conservation of currently existing genetic variability, and to prevent stochastic and demographic collapse, the plan requires a minimum of 2 reserves of at least 100 flowering plants that occur within a 0.8-kilometer (0.5-mile) radius of each other in each of the 4 recovery zones.

The importance of individual recovery units to *Fritillaria gentneri* relies on providing for the distribution of *Fritillaria gentneri* across their native range and maintaining adaptive ability to ensure long-term persistence. When total population numbers within the recovery unit fall below 500 individual flowering *Fritillaria gentneri* plants, these populations will experience the accumulation of deleterious alleles which ultimately result in population declines and extirpation (Soulé 1987, Yonezawa *et al.* 2000). In order for the species to survive and recover in the future, all the genetic diversity across the total range of the species must be conserved in order to provide the species with adaptive abilities when the future environments change. Since each of the recovery units are based on preserving the genetic differentiation across the species range, all of these recovery units are necessary for both the survival and recovery of the species. Thus, the loss of all the unique genetic material from one of the recovery units may spell extinction for the species when the environment undergoes a rapid change. Having reached this conclusion, that these recovery units are necessary for both the survival and recovery of the species, we shall consider the effects of proposed Federal actions undergoing section 7 (of the Endangered Species Act) consultation on the recovery unit, rather than on the species as a whole. This means that a determination that a proposed Federal action violates section 7(a)(2)'s prohibition against jeopardizing the continued existence of a listed species need only consider effects to a recovery unit, and not wide ranging effects to the species as a whole.

To be counted toward the recovery objective, reserves within recovery units must consistently maintain adequate numbers of *Fritillaria gentneri* plants. Population size is calculated by counting the number flowering plants present in reserves. Because this species spreads through vegetative reproduction (bulbils), individual, independent plants may not represent genetically distinct individuals.

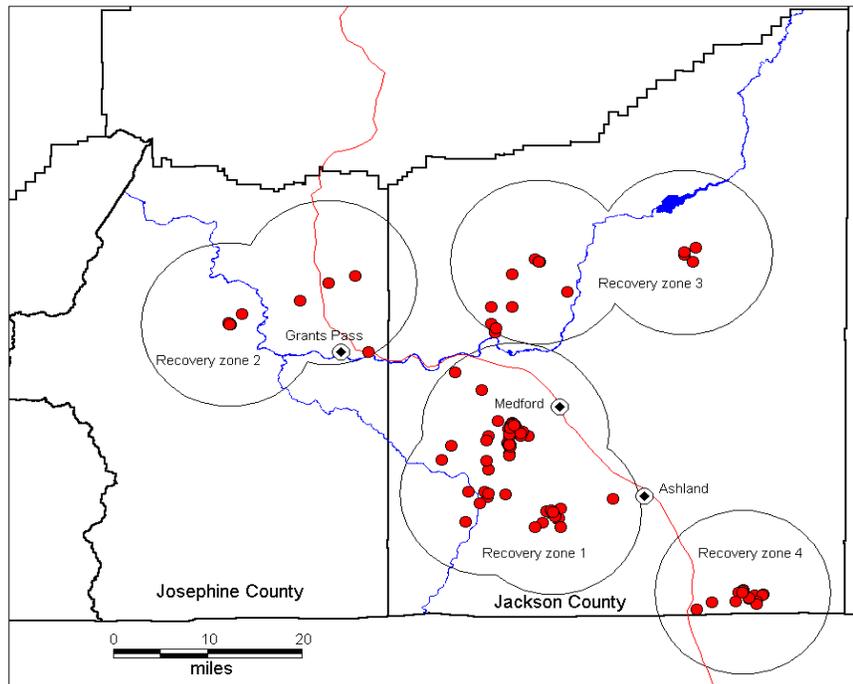


Figure 5. Recovery zones for *Fritillaria gentneri*. These four zones are delineated with the intent of capturing existing geographical distribution patterns and maximizing the preservation of ecological and genetic variability in the species. The distribution of recovery zones, and the allocation of populations within them, may change as new information is gained about the extent and distribution of genetic diversity between populations.

Measures of occupied habitat, combined with counts of flowering plants, provide a practical method for evaluating the viability of both extant, re-established, and newly created populations.

Both extant historic, re-established, and newly created populations will require management. Encroaching vegetation must be controlled, and populations may require periodic augmentation. Various land management regimes should be evaluated for efficiency, and prescribed management adjusted accordingly.

PART II. RECOVERY

A. OBJECTIVES AND CRITERIA

The objective of this recovery plan is to outline recovery actions that, when implemented, will remove threats to *Fritillaria gentneri* to the extent that it is no longer in danger of extinction, at which point it may be warranted to downlist the species to threatened status or delist from the Federal list of endangered and threatened plants. In the Final Rule to list *Fritillaria gentneri* as an endangered species (64 FR 237, 1999), we identified several key threats (Reasons for Listing) that must be adequately addressed before reclassification of the species to a threatened status or delisting can be considered. Appendix F links recovery criteria to the five listing factors and the recovery tasks. These Reasons for Listing are also discussed in Part I of this recovery plan, and in descending order of magnitude are:

- Ongoing loss of habitat to development
- Vulnerability associated with small population sizes
- Lack of habitat management needed to maintain favorable, mid-successional conditions
- Inadequacy of regulatory mechanisms to conserve the species
- Potential for bulb collecting
- Fungal disease and herbivory

Reclassification and delisting requires the establishment, management, and maintenance of a minimum of eight reserve populations, distributed within four recovery zones, where the species will be secure from all threats described in the Reasons for Listing in Part I of this plan and when the following criteria are met:

Each recovery zone shall maintain at least 750 flowering plants to consider reclassification to threatened status, and 1,000 flowering individuals to consider delisting. These plants must be secure from all threats identified in the Reasons for Listing. This size criterion is most strongly supported by research conducted by Yonezawa *et al.* (2000), who indicated a minimum of 20,000 individuals (flowering and non-flowering) would be needed to conserve normal levels of adaptive genetic variance under a balance of mutation and random genetic drift in populations of the related clonal species, *Fritillaria camtschaticensis* (Kamchatka fritillary). If these findings can be

generalized to *Fritillaria gentneri*, then reserve population sizes of 1,000 flowering individuals should be adequate to maintain sufficient adaptive genetic variance, as flowering individuals are typically vastly outnumbered by accompanying non-flowering plants. A population with 1,000 flowering plants is estimated to range from 20,863 to 61,278 total plants (Appendix E). To maximize and maintain potential genetic, ecological, and geographical variation in the species, reduce vulnerability to adverse random events, and maintain current distributional patterns, at least 2 areas (of at least 100 individuals that occur within 0.8-kilometer of each other) within each of the 4 recovery zones will be established (Figure 5). These four recovery zones reflect observable geographical groupings of known and historic *Fritillaria gentneri* locations. Designation of additional recovery zones, and/or changes to the boundaries, may be warranted if additional population centers are discovered, and/or if future research into the distribution of genetic diversity (Recovery Action 3.5) suggest other, more appropriate boundaries.

The populations of *Fritillaria gentneri* within each recovery zone will be considered secure from the threats identified in Reasons for Listing when the following criteria are met:

- (1) To avoid the threat of habitat loss, the reserve areas within the recovery zones identified for recovery should be located on public land, or private land subject to permanent conservation easement or other permanently binding agreements. Because populations elsewhere on public land continue to experience loss and degradation of habitat, each agency involved in land ownership or management in association with a reserve area should take appropriate steps to ensure the long term conservation of this species by outlining their specific responsibilities for site protection and maintenance in land management plans, conservation agreements, and the like;
- (2) To remove threats inherent among populations comprised of too few and too widely scattered individuals, 2 of the reserve areas within each recovery zone must consist of at least 100 flowering individuals within a 0.8-kilometer (0.5-mile) radius, and exhibit net demographic stability or growth for at least 15 years, as determined through annual demographic monitoring. For the purposes of this plan, measurements of population size and structure are based only on flowering individuals because non-flowering plants cannot be reliably identified to species. If necessary, reserve area may be subject to augmentation using genetically appropriate cultivated individuals to meet the minimum size criterion (Recovery Action 2.43). Reserves should contain ample habitat to provide a spatial buffer around each population, and allow

room for population migration and expansion over time;

- (3) To avoid population vulnerability arising from the inordinate concentration of individuals within a very small area, potentially subject to unpredictable catastrophic events, flowering individuals must be distributed over a minimum of 500 square meters (0.05 hectares or 0.12 acres) of occupied habitat¹ within each recovery area. Thus, reserve populations may have more than the minimum of 1,000 flowering individuals if their distribution, densely confined to a small area, falls short of the occupied habitat requirement;
- (4) To maintain favorable habitat conditions, a site-specific habitat management plan will be developed for each reserve area to prevent colonization of invasive weeds and maintain favorable mid-successional characteristics;
- (5) To protect plants from bulb collecting and herbivory by deer, each reserve area will be subject to fencing or other measures if annual population monitoring determines these threats are real threats; and,
- (6) To protect plants from fungal disease, each reserve area will be subject to treatment with fungicides or other measures if annual population monitoring determines these threats are real threats.

¹ “Occupied habitat” is defined based on a vegetation sampling procedure employed by the Service using 1 by 1 meter plots that are scored for the presence or absence of *Fritillaria gentneri*. A plot with one or more *Fritillaria gentneri* flowering stems is considered a square meter of occupied habitat.

B. STEPDOWN OUTLINE OF RECOVERY ACTIONS

1. Provide private landowners with information on identification and management of habitat to maintain *Fritillaria gentneri*
 - 1.1 Develop identification guide for *Fritillaria gentneri*
 - 1.2 Provide technical assistance to private landowners
2. Establish a minimum of eight reserve populations (allocated among recovery zones as detailed in Objectives and Criteria)
 - 2.1 Select reserve areas
 - 2.2 Delineate reserve boundaries
 - 2.3 Secure protection of habitat within reserve areas
 - 2.4 Meet minimum population size, structure, and stability criteria
 - 2.41 Conduct baseline demographic monitoring
 - 2.42 Assess population augmentation needs
 - 2.43 Augment populations as necessary
 - 2.431 Collect rice-grain bulblets from genetically suitable sources
 - 2.432 Cultivate bulblets into larger plants and outplant into reserve populations
 - 2.44 Conduct annual monitoring to evaluate compliance with size, structure, and stability of the population, to determine efficacy of management plan implementation, and to

evaluate impacts of illegal bulb collecting, herbivory by deer and livestock, and severity of fungal infections

2.5 Manage each reserve population area

2.51 Develop habitat management plans for each reserve area

2.52 Implement habitat management plans for each reserve area

3. Conduct additional surveys and research

3.1 Continue surveys for undiscovered populations

3.2 Research habitat requirements

3.3 Develop chemical, anatomical, or other methods to distinguish non-flowering *Fritillaria gentneri* from its congeners

3.4 Research population responses to experimental habitat management treatments

3.5 Research the extent and distribution of genetic diversity within the species (within and between populations)

3.6 Research off-site cultivation and outplanting of plants grown from bulblets

3.7 Research potential for sexual reproduction

3.8 Determine if *Fritillaria gentneri* is a hybrid

3.9 Determine feasibility of bulb salvaging

4. Develop off-site germplasm bank

4.1 Develop off-site storage methods

4.2 Establish off-site germplasm banks

5. Review and revise recovery plan as needed, based on accumulation of new data

C. NARRATIVE OUTLINE OF RECOVERY ACTIONS

1. Provide private landowners with information on identification and management of habitat to maintain *Fritillaria gentneri*

Although the primary focus of recovery efforts will lie in the establishment of secure reserve populations, conservation of all extant occurrences, even those in private ownership that only contain a few individuals, remains a critical goal of this plan. These populations contribute to the overall abundance and distribution of the species and may harbor genetic variability important for conservation and recovery efforts.

1.1 Develop identification guide for *Fritillaria gentneri*

Because of the closely related scarlet fritillary, identification is challenging for the professional if not almost impossible for the amateur. Thus, an identification guide with a key identifying characters diagramed and photographed and comparisons with closely related species is needed in order for the general public to accurately identify *Fritillaria gentneri*. Once this guide is developed and published, it should be made available to the general public. This guide will allow landowners to determine if they have *Fritillaria gentneri* on their property and they may possibly want to protect it.

1.2 Provide technical assistance to private landowners

We will take steps to prevent further habitat loss on these private lands by providing information on identification and management so that private landowners who wish to protect *Fritillaria gentneri* may be able to do so. This outreach effort could lead to

establishment of conservation agreements, conservation easements, land acquisition, or other types of agreements. Conservation agreements should outline specific steps necessary to conserve the species, and encourage habitat improvement through programs such as our Partners for Fish and Wildlife Program or others.

2. Establish minimum of eight reserve populations (allocated among four recovery zones as detailed in Objectives and Criteria)

The core of recovery efforts for *Fritillaria gentneri* will lie in the establishment of at least 8 reserve populations (2 of the reserve areas within each recovery zone must consist of at least 100 flowering individuals within a 0.8-kilometer (0.5-mile radius) where the species will be secure from all threats identified in Reasons for Listing. The distribution of these reserve populations within specified recovery zones, minimum population size criteria, and other specifications are detailed in Objectives and Criteria.

2.1 Select reserve sites

Locations of reserve populations in the four recovery zones will be selected in consultation with individual private landowners, public land managing agencies, and other knowledgeable and interested parties.

The most suitable sites will be selected based upon factors including land ownership, extent and quality of habitat, health and size of existing populations, threats from current or projected land uses, site management needs, feasibility of providing habitat management in light of surrounding land uses, and security of sites from vandalism and trespass.

2.2 Delineate reserve boundaries

Boundaries of selected reserves should be accurately mapped to ensure precision and efficiency in habitat acquisition and/or development of conservation agreements and easements, and help

avoid unintentional habitat disturbance resulting from management of adjacent lands. Adjacent landowners should be notified of reserve boundaries to avoid inadvertent trespass.

Factors to consider when delineating reserve boundaries include provision of adequate unoccupied habitat to allow for population expansion, provision of buffers around the population to diminish impacts from surrounding land uses and edge effects, natural distributional patterns of plants and habitat, and patterns of land ownership. Once reserve boundaries have been identified, they should be accurately recorded in formats useful to reserve land managers.

2.3 Secure protection of habitat within reserve areas

Populations of *Fritillaria gentneri* on private lands are not legally protected against habitat loss. Likewise, the occurrence of *Fritillaria gentneri* populations on public lands has not historically guaranteed their protection against inadvertent disturbance. As such, wherever reserve populations are established, they should be reliably protected through formation of permanent, legally binding agreements between us and the landowners. Conservation agreements must outline the specific steps needed to protect reserve populations, and the liabilities of failing to carry out specified protection measures. Establishment of conservation agreements should be coupled with development of site-specific habitat management plans, discussed below (Recovery Action 2.5), to provide for long-term maintenance or improvement of habitat.

2.4 Meet minimum population size, stability, and structure criteria

In order to meet the criteria for recovery, each recovery zone must consist of at least 750 flowering plants for reclassification and 1,000 plants for delisting, and contain a minimum of 500 square meters (0.12 acres) of occupied habitat for each recovery zone (see Recovery Criteria). The steps needed to meet these criteria are discussed below.

2.41 Conduct baseline demographic monitoring

Reserve populations should undergo baseline monitoring to determine their initial size (quantity of individuals), distribution of individuals within the habitat (including assessment of occupied habitat), and the frequency of individuals within different age (size) classes. This information will be useful in assessing augmentation needs and provide baseline information for use in evaluating efficacy of management strategies.

2.42 Assess population augmentation needs

Once baseline demographic information has been collected, augmentation needs should be assessed to achieve, within each recovery zone, the recovery criterion of 1,000 flowering plants. Little is known about how long it takes to cultivate mature, reproductive *Fritillaria gentneri* plants from rice-grain bulblets, though other species typically require 3 to 5 years (Pratt and Jefferson-Brown 1997), so the process of achieving 1,000 flowering plants may take several years. To buffer against demographic stochasticity over time, efforts should be made at the outset to exceed the minimum number of 1,000 flowering plants.

2.43 Augment populations as necessary

The following steps are recommended as protocols for population augmentation, and are based upon information gained from preliminary cultivation efforts currently being undertaken by Oregon Department of Transportation. It may be useful to update these recommendations if and when this recovery plan is revised, as additional experience and information is gained from continued cultivation and outplanting research (Recovery Action 3.6).

2.431 Collect rice-grain bulblets from genetically suitable sources

To maintain the genetic integrity of *Fritillaria gentneri* populations, and maximize potential genetic diversity among reserve areas and recovery zones, all augmentation activities should be limited to the use of genetically appropriate, local bulb stock, preferably from the existing population at each reserve area (unless future data provide evidence that populations unduly suffer negative consequences of genetic uniformity, or there is no diversity among certain populations). In the unlikely event that a reserve area does not already harbor a *Fritillaria gentneri* population, then the nearest neighboring population should be used as the source of cultivation and augmentation stock.

As competition between bulblets is probably extremely intense at the base of parent plants in natural populations (i.e., Figure 3), due to crowding, careful collection of a few bulblets from mature plants should have little, if any, impact on population dynamics while simultaneously providing valuable cultivation stock. Efforts should be made to collect bulblets from a range of individuals within each population, to maximize the potential genetic diversity of augmentation stock.

2.432 Cultivate bulblets into larger plants and transplant into reserves

Once bulblets are collected from natural populations, they should be cultivated in the greenhouse until they reach a size/age class when transplanting into reserve populations is desired. Additional research is needed to determine optimal cultivation techniques, the time

needed to cultivate small plants to reproductive maturity, and to evaluate optimal methods (and seasonal timing) of transplanting mature bulbs into the field. Preliminary research into cultivation techniques is currently underway by Oregon Department of Transportation, and additional cultivation and augmentation research is under proposal as a challenge cost-share project between Oregon Department of Transportation and Medford Bureau of Land Management.

2.44 Conduct annual monitoring to evaluate compliance with size, structure, and stability of the population, to determine efficacy of management plan implementation, and to evaluate impacts of illegal bulb collecting, herbivory by deer and livestock, and severity of fungal infections

Reserve populations should undergo annual monitoring to determine if populations are stable, project long-term population trends in population growth or decline, learn more about the life history of the species (i.e., plant longevity, frequency of dormancy, and rate of transitions between age/size classes), measure spatial changes in populations, evaluate compliance with minimum size and structure (occupied habitat) criteria, and assess future augmentation needs. If conducted in concert with implementation of habitat management measures, monitoring will also provide data to evaluate the efficacy of habitat management strategies.

Implementation of management plans should be conducted in concert with population monitoring, as a means of evaluating the response of populations to management actions. In some instances when the outcome of management strategies is uncertain, it may be wise to exercise caution and implement them on a small-scale, experimental basis, prior to large-scale implementation.

Monitoring of reserve populations should be conducted on an annual basis to evaluate the severity and impacts of herbivory by deer and loss of bulbs to collectors. If these factors become problematic, occurring at levels considered to be detrimental to the long-term health of populations, then actions should be taken to reduce their levels through fencing, repellants, or other means.

Monitoring of reserve populations should be conducted on an annual basis to determine the severity of fungal infections and other diseases. If diseases become so problematic that they constitute a real threat to populations, then actions, such as treatment with fungicides, should be taken to reduce their severity. Research should also be conducted to determine the identity of pathogens and any environmental factors that may be exacerbating their severity.

2.5 Manage each reserve population area

Passive protection of *Fritillaria gentneri* from human disturbance will likely be inadequate to maintain the species in perpetuity in its degraded and changing environment. In addition to protection, comprehensive habitat management will be needed to encourage natural population recruitment and sustain reserve populations in the long-term.

2.51 Develop habitat management plans for each reserve area

Management strategies should be developed for each reserve on an individual basis, determined by the needs and habitat characteristics at each site, as assessed by us, affected landowners, and consulted knowledgeable individuals.

Management strategies may include, but are not limited to:

- Reduction of successional encroachment and shading by

means of prescribed fire, mowing, pruning, selective removal of trees and brush, or other means

- Control and prevention of invasive weed colonization through annual monitoring, manual removal, biocontrol, herbicide application, mowing, or other means
- Reduction of herbivory by deer through fencing or repellants
- Prevention of bulb collecting through public education, fencing, or other means
- Reduction of fungal disease by use of fungicides or other means
- If conditions that promote sexual reproduction are discovered through future research (Recovery Action 3.7), these conditions should be enhanced to facilitate increased seed production

2.52 Implement habitat management plans for each reserve area

Once developed, management strategies should be incorporated into a written plan with a detailed implementation schedule.

3. Conduct additional surveys and research

The following actions are recommended to increase our knowledge of *Fritillaria gentneri* and assist in developing effective recovery strategies for the species.

3.1 Continue surveys for undiscovered populations

New populations of *Fritillaria gentneri* continue to be discovered, even though botanists and amateurs alike have searched for this showy species for several decades. This is in part due to large-scale surveys recently conducted on Bureau of Land Management and other lands, as well as our information requests publicized in area newspapers. Discovery of new *Fritillaria gentneri* populations increases the prospects for its recovery not only by elevating the number of known plants and providing new opportunities for their conservation, but also by enhancing our knowledge of the species' habitat requirements, geographical distribution, and response to various land use regimes.

When considering priorities for future surveys, emphasis should be given to private lands (with voluntary landowner cooperation), where the threat of land development and habitat loss is most immediate. Priority should also be given to surveying suitable habitats (as determined by task 3.2) in areas immediately beyond the perimeter of known populations, so that we may become more confident about the limits of the species' geographic range and provide land managers with more precise information about where project clearance surveys are warranted.

If chemical, anatomical, or other diagnostic methods are successfully developed for distinguishing *Fritillaria* species when in the vegetative stage (Recovery Action 3.3), these methods should be utilized in all future surveys to assist in accurate identification of non-flowering plants in the field. These techniques should also be used to re-evaluate the identity of non-flowering plants, and extent of occupied habitat, in known populations and previously surveyed areas.

Targeting of surveys may be assisted in the future by completion of research into *Fritillaria gentneri* habitat requirements and soil affinities (Recovery Action 3.2).

3.2 Research habitat requirements

To assist in the efficient implementation of targeted surveys for new *Fritillaria gentneri* populations, it would be helpful to develop a means of identifying and prioritizing the most suitable and promising sites. One way of doing this would be to collect detailed habitat information (including soils, associated species, elevation, etc.) from all known *Fritillaria gentneri* populations, and then use statistical analysis and geographic information system (GIS) to predict the areas with the highest potential of harboring the species. Preliminary information on soils occupied by known *Fritillaria gentneri* populations has already been compiled by Andy Robinson, and is summarized in Appendix D.

Collection of comprehensive habitat information would also be useful in selecting reserve population locations, defining reserve boundaries, identifying augmentation areas within reserves, and refining management strategies and goals for reserve (and non-reserve) populations.

3.3 Develop chemical, anatomical, or other methods to identify non-flowering plants

Because their basal leaves appear virtually identical, it is currently considered impossible to distinguish *Fritillaria gentneri* from *F. affinis* and *F. recurva* when not in flower. As non-flowering plants predominate populations of these co-occurring species, a means of confidently differentiating their leaves is greatly needed to accurately determine their abundance and distribution, and to assist land managers in protecting *Fritillaria gentneri* from potentially destructive land actions. Efforts should be made to develop methods for distinguishing fritillary leaves, preferably using chemical, anatomical, or other techniques that are more practical, portable, and expedient than molecular analysis.

3.4 Research population responses to experimental habitat manipulations

Currently, habitat management recommendations for *Fritillaria gentneri* are based only on best estimates of habitat requirements. Nothing is known about how this species, and its various life history stages and population dynamics, respond to different management strategies. Topics needing further investigation and experimentation include, but are not limited to the following:

- (A) Populations response to shading, or release from shading
- (B) Effects of manual removal of shrubs and trees on the species, and potential inadvertent proliferation of invasive weeds
- (C) Determine conditions for and effectiveness of burning as a tool for reducing fuels (preliminary investigations into this question are currently under proposal as a challenge cost-share project between Oregon Department of Transportation and Medford Bureau of Land Management)
- (D) Determine benefits to *Fritillaria gentneri* from ground disturbance, as suggested by its occurrence along old roadbeds, bulldozer grades, and trails
- (E) Determine frequency and intensity of implementation of management techniques

Understanding the most fundamental management-related questions must be sought to promote successful establishment of reserve populations and ensure development of strategies that will benefit, and not further jeopardize, *Fritillaria gentneri*.

3.5 Research the extent and distribution of genetic diversity within the species (within and between populations)

Little is currently known about the level of genetic diversity within and between populations of *Fritillaria gentneri*. Certainly there is quite a bit of morphological variation within the species, but the degree to which this is influenced by genetic and environmental interactions is unknown. Since conservation of adaptive genetic variability in *Fritillaria gentneri* is a fundamental goal of this plan, resolving this issue would provide important information needed to evaluate the current delineation of recovery zones, and assist in the selection of optimal reserve areas. This information would also be useful in determining the extent to which populations consist of genetically uniform clones, and hint at the history of founder effects, sexual reproduction, and accumulation of mutations experienced by different populations.

3.6 Research optimal cultivation and outplanting techniques

Successful augmentation of *Fritillaria gentneri* reserve populations, for purposes of increasing the number of flowering plants and achieving stable population sizes and spatial structures, will hinge on developing effective methods of cultivation and re-introduction. To date, Oregon Department of Transportation has had preliminary success cultivating plants in the greenhouse using small bulblets and mature bulbs, but it is still unknown how long it will take these plants to reach reproductive maturity. Likewise, the optimal size, method, and timing of bulb transplanting (i.e., fall, winter, or spring) remain unknown. As existing populations are far too small to meet the reserve population requirements in this plan, it will be very important to resolve these questions. Preliminary research into cultivation and outplanting methods is currently under proposal as a challenge cost-share project between Oregon Department of Transportation and Medford Bureau of Land Management, information from which will hopefully begin to fill in the gaps in our understanding of these questions.

3.7 Research potential for sexual reproduction

Despite years of formal and informal investigations into seed production in *Fritillaria gentneri*, actual viable seeds have not been documented in this species (R. Meinke, pers. comm. 2001). Nevertheless, rumors of seed production persist, fueling curiosity about the potential for sexual reproduction, perhaps under infrequent or ecologically unique circumstances. As discussed above in Reproductive Ecology, there is reason to believe that high levels of pollen sterility may account for low seed set levels, but there is a difference between “low seed set” and “no seed set,” and the extent of sterility across all individuals and populations remains unknown. As such, though researchers have not yet documented successful seed production, the possibility for such, perhaps involving certain parental combinations, has still not been conclusively ruled out.

Understanding the nature of circumstances required for successful seed production, if they exist, would be significant for *Fritillaria gentneri* conservation and recovery, as it might enable land managers to enhance population attributes that promote seed production. In turn, increased sexual reproduction could enhance levels of adaptive genetic variation within populations, encourage formation of seed banks, and provide additional stock for cultivation and off-site seed banking projects. In contrast, if seeds are not ultimately yielded by this research, we may more definitively conclude that *Fritillaria gentneri* does not in fact reproduce sexually, and also better understand the mechanisms and obstacles that function to prohibit seed production.

3.8 Determine if *Fritillaria gentneri* is a hybrid

Initial studies by Guerrant (1992) indicated that *Fritillaria gentneri* was not a hybrid. However, the lack of seed production and possible sterile pollen are indicators that the plant may be a hybrid and not a valid taxon. Additional research should be conducted so as to be able to confirm that *Fritillaria gentneri* is

not a hybrid.

3.9 Determine feasibility of bulb salvaging

There may be opportunities to salvage mature bulbs of *Fritillaria gentneri* from private lands that are slated for development. Currently there are three lots in Jacksonville Cemetery that would be prime salvage spots (B. Schroeter, pers. comm. 2001). The questions to be answered are when is the best time of the year to salvage the bulbs, how should the bulbs be stored until needed, when is the best time to outplant, should bulbs be marked when in flower if transplant is after they have gone dormant?

4. Develop off-site germplasm

One of the fundamental goals of establishing large reserve populations is to reduce the threat of species' extirpation by random catastrophic events, such as pest and disease outbreaks, vandalism, intense wildfires, unfavorable climatic events, etc. However, as *Fritillaria gentneri* does not appear to produce seeds, and therefore probably lacks a seed bank, resiliency of populations to such events may prove more crippling and irreversible than for seed-producing species. Not only are seed-producing plants capable of forming natural soil seed banks, but their seeds can also be used to develop artificial (off-site) seed banks, thus providing additional security against threats in their environment.

4.1 Develop off-site storage methods

Since seed is not reliably produced, another method of germplasm storage needs to be developed. Investigations into the feasibility of storage of bulblets in cold storage for prolonged periods versus outplanting of bulbs in gardens should be investigated. The danger in outplanting in gardens is contamination from other *Fritillaria* species that may be present from cross pollination with seeds being produced and becoming established in the germplasm beds. Thus, if the only way to preserve germplasm of *Fritillaria gentneri* is in

“gardens”, protocols on how to establish these “gardens” so as not to have contamination problems need to be developed.

4.2 Establish off-site germplasm banks

To provide added security for *Fritillaria gentneri*, an off-site germplasm should be established where a representative number of individuals from each reserve population (and additional non-reserve populations, if possible) are maintained in cultivation. This could be done in concert with the cultivation efforts that take place to provide stock for reserve population augmentation. In the event *Fritillaria gentneri* eventually proves capable of producing viable seeds, a seed collection and off-site banking program should be initiated, and cultivated individuals in the germplasm should be kept reproductively isolated (by population) to prevent the potential for unintentional cross-pollinations.

5. Review and revise recovery plan based on accumulation of new data

As new information about *Fritillaria gentneri* becomes available through additional surveys, research, and management experience, the objectives, criteria, and recovery actions in this recovery plan should be reviewed and revised, as necessary. Of specific importance may be evaluations of recovery zone delineations, allocation of reserve populations within recovery zones, the size and structure criteria of reserve populations, and future research and management needs.

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PART IV. IMPLEMENTATION SCHEDULE

The following Implementation Schedule is a guide for meeting the objective discussed in Part II of this recovery plan. This schedule indicates task priorities, task numbers, brief task descriptions, duration of tasks, the responsible agencies, and lastly, estimated costs. These actions, when accomplished, should bring about a level of species' conservation and habitat protection, such that downlisting from endangered to threatened is merited. Priorities in column one of the following implementation schedule are assigned as follows:

Priority 1 : An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 : An action that must be taken to prevent a significant decline in the species' population/habitat quality or some other significant negative impact short of extinction.

Priority 3 : All other actions necessary to meet the recovery objective.

Key to acronyms and other words or phrases used in the Implementation Schedule:

Annual - cost occur annually until species recovered

Ongoing - once a project starts, cost will occur annually until species is recovered

BLM - Bureau of Land Management

CITY- City of Jacksonville and Jacksonville Woodland Association

FS - U. S. Forest Service

FWS - U.S. Fish and Wildlife Service, Oregon State Office

ODA - Oregon Department of Agriculture

* - An asterisk denotes the lead responsible agency

Recovery Plan Implementation Schedule for *Fritillaria gentneri*

Task Priority	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost	Cost Estimates, in thousands of dollars per fiscal year									
						FY1	FY2	FY3	FY4	FY5	FY6	FY7	FY8	FY9	FY10
1	1.1	Develop identification guide	1	FWS* ODA BLM	5	5									
1	1.2	Provide technical assistance	Annual	FWS* ODA BLM CITY	50	5	5	5	5	5	5	5	5	5	5
1	2.1	Select reserve sites	1	FWS* ODA BLM CITY	3			3							
1	2.2	Delineate boundaries	1	FWS* ODA BLM CITY	10			10							
1	2.3	Secure habitat	5	FWS* ODA BLM	320			40	40	40	40	40	40	40	40
2	2.41	Conduct baseline demographic monitoring	5	FWS* ODA BLM CITY FS	400				80	80	80	80	80		

Task Priority	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost	Cost Estimates, in thousands of dollars per fiscal year									
						FY1	FY2	FY3	FY4	FY5	FY6	FY7	FY8	FY9	FY10
2	2.42	Assess population augmentation needs	Ongoing	FWS ODA* BLM CITY FS	35				5	5	5	5	5	5	5
2	2.431	Collect rice-grain bulblets	Ongoing	FWS ODA* BLM CITY FS	60					10	10	10	10	10	10
2	2.432	Cultivate bulblets into larger plants and outplant	Ongoing	FWS ODA* BLM CITY FS	200						40	40	40	40	40
2	2.44	Conduct annual monitoring	Ongoing	FWS ODA BLM* CITY FS	280				40	40	40	40	40	40	40
2	2.51	Develop habitat management plans	2	FWS ODA BLM* CITY FS	80				40	40					

Task Priority	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost	Cost Estimates, in thousands of dollars per fiscal year									
						FY1	FY2	FY3	FY4	FY5	FY6	FY7	FY8	FY9	FY10
2	2.52	Implement habitat management plans	Ongoing	FWS ODA BLM* CITY FS	200						40	40	40	40	40
2	3.1	Survey for undiscovered populations	5	FWS ODA BLM* CITY FS	100	20	20	20	20	20					
2	3.2	Research habitat requirements	3	FWS ODA* BLM CITY FS	60	20	20	20							
2	3.3	Develop methods to distinguish non-flowering plants	3	FWS ODA* BLM CITY FS	60	20	20	20							

Task Priority	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost	Cost Estimates, in thousands of dollars per fiscal year										
						FY1	FY2	FY3	FY4	FY5	FY6	FY7	FY8	FY9	FY10	
3	3.8	Determine if hybrid	3	FWS ODA* BLM CITY FS	30	10	10	10								
3	3.9	Determine feasibility of bulb salvage	2	FWS ODA* BLM CITY FS	20	10	10									
3	4.1	Develop off-site storage methods	3	FWS ODA* BLM CITY FS	30	10	10	10								
3	4.2	Establish off-site germplasm banks	Ongoing	FWS ODA* BLM CITY FS	70				10	10	10	10	10	10	10	10
3	5.0	Review and revise plan	2	FWS* ODA BLM CITY FS	30						15	15				
Totals					2,226	161	156	199	240	250	285	285	270	190	190	